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Segment No. 10-23-13

WA-23-1020

Attachment A

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MEMORANDUM
March 2, 1987

To: Chung Ki Yee, Southwest Regional Office

From: Joe Joy, Water Quality Investigations Section

Subject: Changes in the Consolidated Dairy Products (Darigold) Permit:Computer Model Simulations and Nutrient Evaluation

As you requested, the effects of the Consolidated Dairy Products (Darigold) effluent on Chehalis River dissolved oxygen (D.O.) and nutrient concentrations were evaluated. A simple, one-dimensional, steady-state model (Joy, 1984) for analysis of this section of the Chehalis River was used to simulate D.O. Impacts of the Darigold nutrient load were evaluated using some of the information gained in Joy's (1984) report.

Dissolved Oxygen

The following four simulations were performed, assuming river conditions of a 7-day, 10-year (7Q10) low-flow event (73 cfs) with a seasonally high, but common, river temperature of 20°C:

1. Control conditions - no discharge from Darigold or Chehalis.

2. Chehalis STP discharge without Darigold discharge.

3. Chehalis STP discharge, and Darigold discharge under current permit conditions (present conditions).

4. Chehalis STP discharge, and Darigold discharge under proposed permit conditions.

The Chehalis STP and Darigold discharges are located at river mile (rm) 74.3. The model simulates the D.O. profile in the 6.8-mile reach between rm 74.4 and the Mellen St. Bridge crossing (rm 67.6). This section of the Chehalis River is primarily a long pool with very slow current velocities. Only D.O. losses from BOD and nitrogenous oxygen demand are considered; wind-induced reaeration, and nutrient-caused algal growth with resultant oxygen production or depletion are not considered. The effects of stratification in the deepest portion of the pool (rm 70-67) are also not considered.

Table 1 summarizes the variables used in the simulations and the simulation results. Briefly, the table shows: 2 mg/L D.O. is lost due to natural conditions; an additional 1 mg/L D.O. is lost when the Chehalis STP discharge is added; and no significant additional D.O. losses are apparent when the Darigold discharge is added under either permit condition. The receiving water to Darigold wastewater dilution ratio of roughly 100:1 at the 7Q10 event protects the river from direct D.O. losses.

Nutrients

Nutrient stimulated algal production in this section of the Chehalis River and its effects on water quality have been documented in recent surveys (Yake, 1980; Johnson & Prescott, 1982; Joy, 1984). The surveys suggest phytoplankton is likely a major source of metalimnetic oxygen depletion in the stratified deep pool at rm 70-67. In addition, the Chehalis STP effluent and unidentified waste sources above rm 74.4 have created a nitrogen-limited system during the July-September algal growing season between rm 74.4 and rm 67.6; i.e., there is an abundance of phosphorus compared to nitrogen available for algal growth, therefore the nitrogen supply will control the potential algal standing crop.

A comparison of upstream nutrient loads to Chehalis STP nutrient loads during the 1979, 1980, and 1982 surveys was made by Joy (1984) and is presented in Table 2. The comparison suggested that at that time (before there was a Darigold discharge to the river), the Chehalis STP contributed a majority of the total inorganic nitrogen (TIN), but only half the total nitrogen observed at rm 74 because upstream sources contributed a majority of the organic nitrogen load (TIN + organic N = total N). This finding was a very rough estimate since few total nitrogen data were available; much of the total nitrogen data was extrapolated from ratios obtained from those few data.

A similar comparison for the current and proposed nutrient loading conditions is more difficult. Since the 1984 evaluation, the Chehalis STP has been upgraded and the Darigold discharge has been installed at rm 74.4. There are no nutrient data for the upgraded Chehalis STP during summer-fall seasons, only spring and winter TIN and phosphorus values (personal conversation with M. Morhous, SWRO, 1987). The frequency with which the STP now experiences denitrification is not known (see Yake, 1980). An assumption was made in the D.O. model that the upgrade has decreased the effluent ammonia concentration from an mean of 13 mg/L to 7mg/L (based on the most recent spring-winter TIN data, and normal STP performance values). This assumption can be carried to the nutrient evaluation as well. However, total nitrogen concentrations for the Chehalis STP and the Darigold plant are absent. Therefore, at this time an estimate of the impact from the total nitrogen load of the Darigold discharge on the river cannot be confidently forecasted for the present and proposed permit conditions. A TIN load comparison can be made with the following assumptions:

- Chehalis STP TIN concentration is 10 mg/L (7mg/L NH_3-N, 3 mg/L NO_3-N)
- Upstream TIN concentration is 0.11 mg/L

The following TIN loads would be present below the discharges based on the above conditions and the present and proposed Darigold discharge permit:

Source	Existing		Proposed	
Chehalis River	43 lbs.	(29%)	43 lbs.	(27%)
Chehalis STP	102 lbs.	(68%)	102 lbs.	(65%)
Darigold	4 lbs.	(3%)	12 lbs.	(8%)
Total	149 lbs.		157 lbs.	

The proposed changes in the Darigold discharge permit would not significantly change the character of the average TIN loading to this section of the river; the load from the STP and upstream sources would still be far more significant. The change in loading would translate to a 0.02 mg/L TIN increase in the river. Not enough is known about the biological processes of the river to judge the significance of the increase. By one theoretical approach this increase in TIN could produce a less than 0.5 mg/L D.O. loss if all of it was converted to algal biomass and then decomposed completely within this section of the river, and if oxygen production by the algae was ignored. This approach is based on the following relationships (Welch, 1980):

$$106\ CO_2 + 90\ H_2O + 16\ NO_3 + 1\ PO_4 + \text{energy} \rightleftharpoons C_{106}H_{180}O_{45}N_{16}P + 154.5\ O_2$$

similarly, the oxygen required to convert: 1 mg P = 160 mg O_2,
1 mg N = 22 mg O_2

therefore, 22 mg O_2 per mg N x 0.02 mg TIN = 0.44 mg O_2

The Southwest Regional Office (SWRO) is aware of the nutrient limiting problem in this section of the Chehalis River. Changes made in the Chehalis STP effluent and Salzer Creek quality have helped to improve the water quality of the river over the past 20 years. The SWRO should consider total nitrogen and phosphorus monitoring of the Chehalis STP and Darigold discharges with the aim of developing a long-range plan to limit the nutrient input to this section of the river.

Conclusions

In summary, the computer simulations of the Chehalis River show no significant direct decline in instream D.O. as a result of the proposed changes in the Darigold discharge permit. In addition, the total inorganic nitrogen load from Darigold appears to be minor in comparison to the loads contributed by the Chehalis STP and upstream sources. Data are not available to evaluate the impact of total nitrogen loads from Darigold or the Chehalis STP, or the significance of the 0.02 mg/L TIN instream increase on algal production in the Chehalis River. The SWRO should consider monitoring nutrients at both major point sources and developing a long-term plan for limiting nutrient loads into this section of the Chehalis River.

JJ:cp

cc: Lynn Singleton, WQIS

REFERENCES

Johnson, A. and S. Prescott, 1982. "Chehalis River water quality data collected July-September, 1980." Memorandum to Howard Steeley, SW Regional Office, Nov. 16. Wash. Dept. Ecology. 5 pp.

Joy, J., 1984. "Evaluation of conditions contributing to the dissolved oxygen problem in the Chehalis River between Chehalis and Centralia." Memorandum to Jon Neel, SWRO, October 29. Wash. Dept. Ecology. 48 pp.

Welch, E., 1980. Ecological Effects of Wastewater. Cambridge University Press, New York, NY. 337 pp.

Yake, W., 1980. "Chehalis wastewater treatment plant Class II inspection." Memorandum to Doug Houck, SWRO, Sept. 25. Wash. Dept. Ecology. 19 pp.

Table 1. Major variables and simulation results for the impact of Darigold discharge on Chehalis River D.O. concentrations between rm 74.4 and 67.6.

	CONTROL	DISCHARGE ADDITIONS		
MODEL INPUT	Chehalis R. no discharges	Chehalis STP w/o Darigold	Darigold current permit	Darigold proposed permit
Flow (cfs):	73	1.9	0.71	0.74
D.O. (mg/L):	8.8	7.3	7.0	7.0
Temp.(deg.C):	20.0	20.0	20.0	20.0
BOD (mg/L):	4.0	30.0	30.0	30.0
NH3-N (mg/L):	0.05	7.00	1.00	3.00
MODEL RESULTS				
Instream D.O.				
rm74.4 (mg/L)	8.8	8.8	8.8	8.8
rm67.6 (mg/L)	6.9	6.2	6.1	6.1
Total D.O. change	1.9	2.6	2.7	2.7
Instream NH3-N				
rm72.6 (mg/L)	0.05	0.23	0.23	0.25
rm67.6 (mg/L)	0.04	0.17	0.17	0.18

Table 2. A comparison of nutrient loads from the Chehalis STP and from the river upstream with the percentage of the combined loads attributed to the STP. Also, the seasonal average contribution of individual nutrient loads based on these data. Loads in units of pounds/day. From Joy, 1984.

Date	7/20/82*	7/30/80*	8/5/80*	8/25/82*	9/16/80	9/27/82*	10/11/79	Seasonal Average (mean ± S.D.)
Total Inorganic Nitrogen								
Upstream load	108	50	54	48	74	75	8	
Chehalis STP load	<165	134	43	108	98	125	224	
Combined load	<273	184	97	156	172	200	232	
% attributed to STP	60.4	72.8	44.3	69.2	57.0	62.5	96.6	66 ± 16
Organic Nitrogen								
Upstream load	65	231	390	65	110	79	63	
Chehalis STP load	31	26	8	21	20	25	52	
Combined load	96	257	398	86	130	104	115	
% attributed to STP	32.3	10.1	2.0	24.4	15.4	24.0	45.2	22 ± 15
Total Nitrogen								
Upstream load	173	281	444	113	184	154	71	
Chehalis STP load	196	160	51	129	118	150	276	
Combined load	369	441	495	242	302	304	347	
% attributed to STP	53.1	36.3	10.3	53.3	39.1	49.3	79.5	46 ± 21
Orthophosphate-Phosphorus								
Upstream load	18	12	6	9	22	15	12	
Chehalis STP load	110	105	82	59	48	40	138	
Combined load	128	117	88	68	70	55	150	
% attributed to STP	85.9	89.7	93.2	86.8	68.6	72.7	92.0	84 ± 10
Total Phosphorus								
Upstream load	27	44	60	18	22	30	24	
Chehalis STP load	125	114	82	64	52	48	138	
Combined load	152	158	142	82	74	78	162	
% attributed to STP	82.2	72.2	57.7	78.0	70.3	61.5	85.2	72 ± 11

*Organic nitrogen data for these dates back-calculated from phosphorus data as described in Appendix I.